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Introduction

Nofima Marin AS has made two experiments studying effects of temperature, during start feeding, on skeletal deformities on cod. The first was done outside of the FineFish project in 2005 (together with 'Troms Marin Yngel' in Norway (a commercial partner)), and the other was a follow-up and was achieved with one part funding from FHF and one part within the FineFish project.

The results of these experiments show a clear relationship between temperature and bone malformation, especially with the abnormal curvature in the neck area, often referred to as "stargazers".

Experimental set-up I

Three temperature regimes were tested out in small scale units (90L tanks) with four replicates per treatment (Figure 1). The cod were either start fed at a constant 12°C or 8°C, or they were subject to a gradual increase from 6°C to 12°C during a seven week period. The fish from the second regime were kept at 6°C for 16 days after start-feeding before the water temperature was increased by one centigrade per week until it reached 12°C.

This latter regime is based on the ambient temperatures in Lofoten during the start feeding period. The experiment was ended when the cod were about 50g, and all fish were radiographed using mammography.

All deviations were registered, classified and axis deviations were graded on a scale from I to IV, where grade I constitutes small deviations, and grade IV the severe deformations.



Figure 1. Experimental start feeding units with water and air temperature control.

Photo: Nofima Marin AS

Results of the first Experiment

The results showed a clear effect of start feeding temperature on the presence of malformations, where the highest number of malformed cod was found in those which were start fed at the highest temperature. A similar picture was seen for the abnormal curvature in the neck (Figure 2), where cod start fed at 12°C had the highest, and cod with a gradual increase from 6°C to 12°C had the lowest level of abnormal curvature of the neck (Figure 3).

At the end of the experiment there was no difference in weight between fish from the constant 12°C and the regime of gradual increase from 6°C to 12°C, while fish from the constant 8°C had a lower final weight.

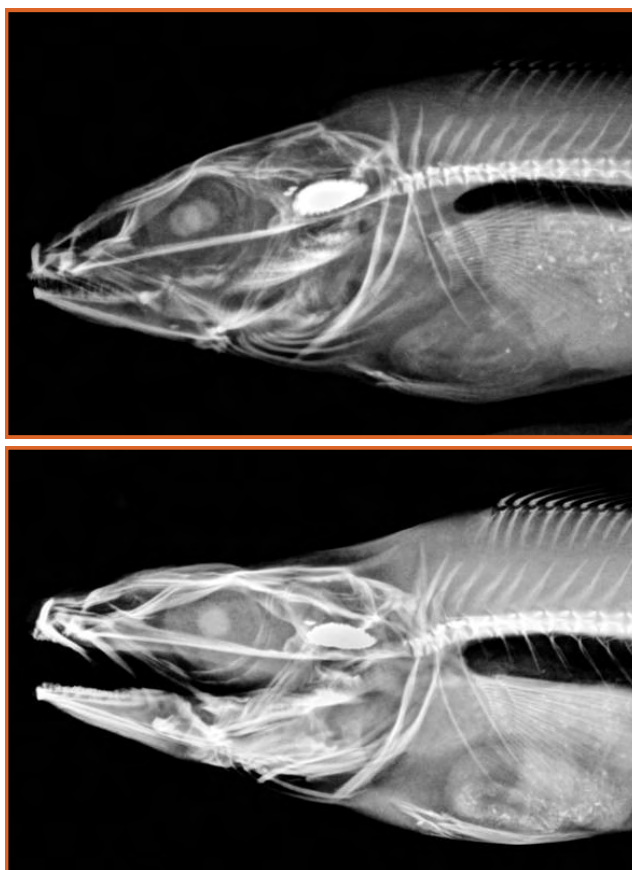


Figure 2. Radiographic image of Atlantic cod juvenile with normal (upper image) and an abnormal (lower image) curvature of the neck (grade II).

Photo: Nofima Marin AS

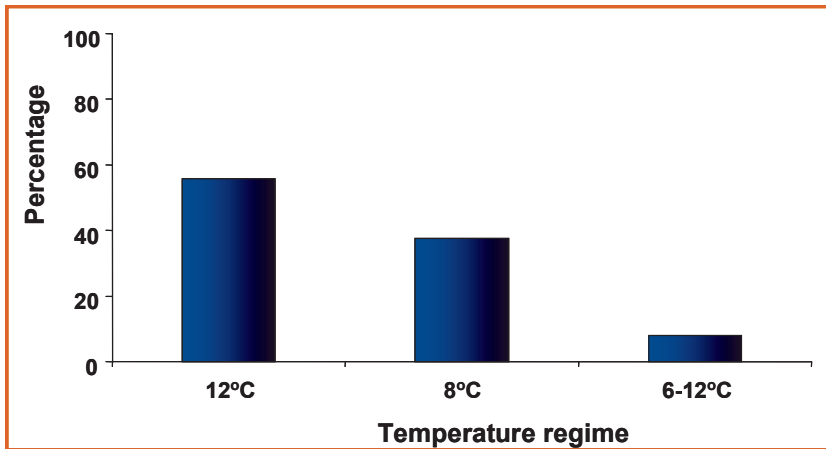


Figure 3. Proportion of Atlantic cod juveniles with abnormal curvature of the neck “stargazers” start fed at three temperature regimes; Constant 12°C, constant 8°C, or a gradual increase from 6°C to 12°C during a seven week period.

Experimental set-up II

Two temperature regimes were tested, both with a gradual increase from 6°C to 12°C. In the control group the increase was done during seven weeks, and in the other experimental group a more rapid increase of five weeks (fast temperature increase) was tested. Otherwise the set-up was the same as in the above described experiment.

Results of the second Experiment

No difference in weight was found between the control group and the ‘fast temperature increase’ group when the experiment was finished at a final weight of 2 gram fish. However, the fish from the most rapid increase were longer than the fish from the control group.

A higher incidence of total number of deformed fish, and of abnormal curvature of the neck, was found in the group start fed at the fastest temperature increase (see Table 1).

Atlantic Cod juveniles	Control group	Fast Temperature Increase
Deformed fish %	13.1%	16.7%
Abnormal curvature of the neck	17.9%	21.9%

Table 1. Total percentage of deformed fish, abnormal curvature of the neck of Atlantic cod juveniles

Conclusions and practical recommendations

The bone formation and the mineralisation processes take place during the start feeding period, and the rearing temperature during this stage therefore has a strong effect on formation and/or malformation of the vertebral column. Skeletal deformities can be induced by several factors. In the cod that were start fed at the temperature regime with the best results from these two experiments, there are still a high numbers of malformations. Thus, it is likely that there are abiotic or biotic factors that are sub-optimal.

Based on the present studies, the temperature regime with the lowest number of malformations, but with no negative impact on final weight, was the gradual increase from 6°C to 12°C during a seven week period. Therefore, it appears that temperature must be controlled, and that it is important not to push growth by increasing the temperature too fast during this early live stage.